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The Canadian Engineer

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Report on Enlargement of Montreal Aqueduct

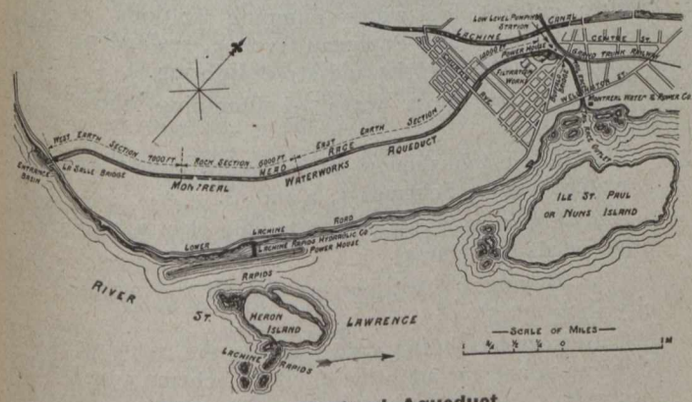
H. E. Vautelet, Arthur St. Laurent and J. B. McRae Discuss Merits of Five Different Schemes Suggested as Solution of Montreal's Civic Power Development Troubles—Review of Project as Designed—Status of the Work

MESSRS. H. E. Vautelet, Arthur St. Laurent and J. B. McRae, who were appointed last fall by the city of Montreal as consulting engineers to report on the aqueduct enlargement and civic power development scheme, presented the following report to the city commissioners and councillors, under date of April 30th, 1917:—

We, the undersigned, by virtue of the duties assigned to us, by a resolution of your board, passed on 6th February, 1917, have the honor to present herewith, our report on the city aqueduct and proposed power development.

To avoid any misunderstanding regarding the report of the ratepaying engineers on the Montreal Aqueduct, addressed to you on November 20th, 1916, we quote from a letter received from Mr. Walter J. Francis, secretary of the committee of ratepaying engineers, on April 24th, 1917:—

"I am instructed to write you to express our regret that a certain erroneous impression seems to prevail regarding the efforts and conclusions of the ratepaying engineers of the city. This is a matter which you will doubtless remember was discussed with you when we last met, and we would merely repeat at this time that our whole object has always been to have the project submitted to an independent board of engineers. The studies which were forced upon us resulted in our concluding (in conclusions 16 and 22) that 'all thought of completing the work *along the present lines* should be abandoned' and that the best should be made of what has been done, by

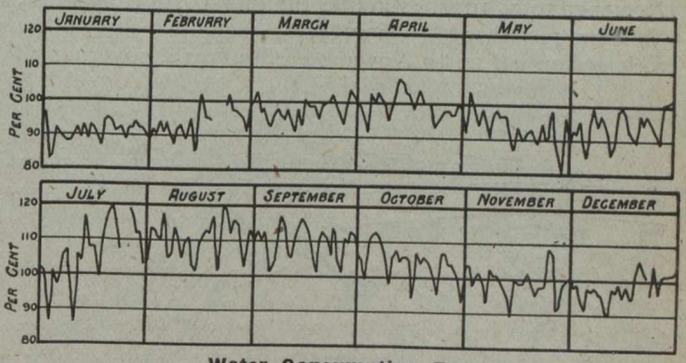


Plan of the Montreal Aqueduct.

the utilization and judicious adaptation of the present conditions. We never advised the complete abandonment of the work, and our references to the abandonment were hypothetical and made for the purpose of indicating the need of the investigation which we have demanded.

"I am instructed to say, on behalf of the ratepaying engineers that, in justice to them we confidently expect you will take occasion in your report, to correct the erroneous impression that complete abandonment was recommended, as stated in the daily press, and, indeed, even mentioned in the preamble of the official resolution appointing your board."

We do not consider it necessary to present here a full history of the aqueduct development since its inception, nor do we consider that we are called upon to do so, in view of the numerous reports already made to the city containing complete historical information on the subject.



Water Consumption Data.

Diagram showing daily pumpage as percentage of yearly average. Compiled from records of low level pumping station. Yearly average, 54,625,462 Imperial gallons=100%. Hourly pumpage varies 35% above yearly average.

It is, however, desirable, before commencing the discussion of the project, in accordance with the above-mentioned resolution, to give a brief outline of the undertaking under progress, its present status as to the amount of work already performed, and expenditure in connection therewith.

Present Project.—The project in course of execution following previous enlargements, consists in the development of the present aqueduct to such dimensions and flow capacity as will enable the hydraulic development of 10,000 h.p. for the purpose of providing electrical horsepower for pumping the water supply needed by the city and for street lighting. It will also supply the water for the city's fire and domestic services.

Before commencing these later enlargements, a lateral concrete conduit of a maximum capacity of 75,000,000 Imperial gallons per day was built to insure a continuous water supply for the city. A filtration plant with a daily capacity of 50,000,000 Imperial gallons has been also built which it is intended, we are informed, to enlarge to a capacity of 100,000,000 Imperial gallons per day. The present aqueduct course is followed in its entire length in the scheme of enlargement.

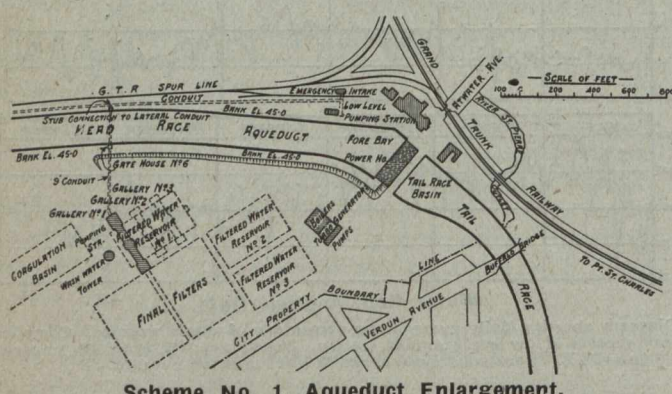
The intake is situated on the St. Lawrence River about one and one-half miles below the Canadian Pacific Railway Co.'s bridge, and the headrace or canal extends to the present waterworks station, a distance of 5.2 miles, where it is proposed to construct the necessary power house, for which no designs have as yet been made.

The headrace has a slope of 3.3 feet for the entire distance, and a bottom width of 163.85 feet. It runs partly in earth and partly in rock material. The bottom elevation at entrance is 21 feet above city datum. The water surface fluctuates from elevation 36 to 43.

The tailrace, which extends from the present waterworks to the St. Lawrence River, opposite Nun's Island, has a total length of about 3,300 feet, a slope of 4 feet, and a bottom width of 113.85 feet. The tailrace excavation will be apparently entirely through earth material. Elevation of the bed at the outlet is 2 feet above city datum. The water surface fluctuates from elevation 8 to 20; flood level has been as high as elevation 28.0.

Both sides of the entrance canal, forebay and tailrace are lined with concrete retaining walls. No paving is provided for the earth sections of the head canal. Paving for the bottom of the tailrace is provided for in the present contract only for the basin below the power house, but we are informed that it is intended to pave the whole of the tailrace, and this paving will, therefore, be considered as part of the present scheme.

Status of Present Work of Enlargement.—The city engineer, in a report to the board of commissioners, dated December 16th, 1916, estimates the total cost of the work, when completed, at $11,600,537.06 including cost of the work performed up to November 28th, 1916, covering all



Scheme No. 1, Aqueduct Enlargement.

Gallery No. 1, Filtration Plant as it is built. Gallery No. 2, proposed extension for 100 M. I. G. Gallery No. 3, proposed extension for 150 M. I. G.

contracts and expenditure since the beginning of the enlargements.

By deducting from the above the total amount of the cost of filtration works, the cost of a pump built in 1908-10 and interest thereon, not chargeable to cost of power development proper, the city engineer arrives at the following figures for the power scheme:—

Cost of work done to November 28th, 1916, including interest	$4,013,510.12
Estimated cost of work yet to be done, including interest	5,581,647.48
Total	$9,595,157.60

The amount of interest included in the total is $1,404,550.

The cost of abandoning the work has been estimated by Mr. Mercier as follows:—

Work done and interest	$4,013,510.12
Work to be done, or payment to make:—	
Bridges and fences	300,000.00
10% on balance of Cook's contract	203,640.00
Power house and building to use the 7,000 h.p. purchased	340,000.00
Construction of another conduit or protection work	1,000,000.00
Total	$5,857,150.12

This is exclusive of large claims against the city in connection with this work, and which will require adjustment.

Work Performed.—The present condition of the work for the entire aqueduct is as follows:—

Earth excavation	About 50% done
Rock excavation	" 90% "
Retaining wall, north side of entrance canal	48% "
Retaining wall, south side of entrance canal	20% "
Forebay and tailrace walls	Nil
Power house	"
Entrance gates, contract yet to be awarded	No work done
Supply conduit	100% done
Expropriations of land required for boulevards, etc.	Not completed

The result of our studies is presented under the following main headings, with such subdivisions of each subject as are necessary for a clear understanding:—

1. Method followed in carrying out the investigation.
2. Frazil.
3. Consumption of water by city.
4. Power actually used for pumping and lighting, and future requirements for pumping and lighting.
5. Definition of the term "horse-power."
6. Project as designed; hydraulic data; velocities.
7. Amount to be spent if work is now abandoned.
8. Scheme No. 1, present scheme.
9. Scheme No. 2, maximum power available.
10. Scheme No. 3, minimum power available.
11. Scheme No. 4, pumping by steam.
12. Scheme No. 5, buying electric current.
13. Lighting.
14. Total cost and cost of operation of all schemes.
15. Financial statement.
16. Remarks on cost.
17. Recommendations.

Method Followed in Carrying Out the Investigation. The needs of the city are as follows:—

Power for pumping water at Atwater Avenue, and electric current for water pumping stations such as McTavish Street and Papineau Avenue, sewage pumping stations, filtration works and street lighting.

There are three ways of obtaining the needed power:—

1. The establishment of a hydro power station at Atwater Avenue (Schemes 1, 2 and 3).

2. Pumping by steam and buying electric current for other needs (Scheme 4).

3. Buying electric current for all the needs of the city (Scheme 5).

A start has been made towards the carrying out of Scheme 1, and the adoption of either Scheme 4 or 5 would necessitate discontinuing the works now in course of execution. We, therefore, had to estimate the cost of making the canal fit for such services as may be required.

If the work be discontinued we have to consider two cases, A and B. In case A (Scheme 4 and 5) the banks of the canal, where walls have not been built, are simply trimmed to a natural slope, without any attempt to secure straight side lines or regular curves, cutting down the expenditure for this purpose as low as possible, leaving the tailrace in its present state.

In case B (Scheme 3), to develop power, the banks of the canal are sloped in straight lines and regular curves to ease off the flow, and the tailrace is enlarged to accommodate the discharge through the headrace.

The cost of case A was found to be $5,895,000 and the amount of interest charged amounts to $1,072,948.

This amount of $5,895,000 has, therefore, to be added to the cost of pumping by steam or by electric current.

If the work is proceeded with, we had again to consider two cases; Case C, connecting the pumps directly to some of the turbines in the power house, and case D, using all the power from the power house to produce electric current, and then using part of the current to operate motor-driven pumps.

The question of connecting the pumps direct to the water-wheels was considered, but on account of the low available head and the resultant slow speed of the turbines, it was found advantageous to operate direct-connected generators in the power house, using the electric power so generated to operate motor-driven pumps. This scheme not only simplifies the design of the pumping units and their connections, but provides a most flexible plant. For example, every turbine unit is available at all times, that it is possible to operate, for either furnishing power for pumping purposes, or any other electric power service required. In the case where the turbine is direct connected to the pump, then that turbine can be used for pumping purposes only.

As the power house at times will not be in operation on account of frazil, high water, etc., and as there is a large difference between summer and winter power, it was also necessary to consider the case of providing an auxiliary steam plant.

We, therefore, calculated the capital cost, cost of maintenance, and cost of operation of the following:—

Canal and tailrace; hydro-electric power house; auxiliary steam electric plant; pump house, operated electrically; stand-by steam pumping plant.

As will be seen, it was found cheaper to discard entirely the old steam pumping plant and build a new one, and finally it was found advantageous to discard this new plant altogether, and enlarge the auxiliary steam electric plant for all requirements.

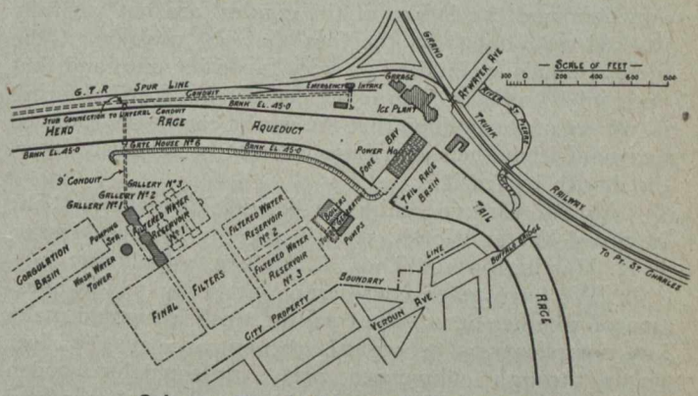
We first calculated the cost of the canal and tailrace as projected (Scheme 1) and the results of our studies, owing to uncertainty due to the nature of the bottom of the canal to resist scouring and the tendency of the retaining walls to slide, led us to calculate the cost of the maximum possible development of power from the canal with paved bottom and maximum enlargement of the tailrace (Scheme 2).

Filtration Works.—The filtration works were built for a capacity of 50 million Imperial gallons per day but are not yet in operation. The average daily quantity of water pumped last year was 54½ million Imperial gallons, running for some periods of three hours, at a maximum rate of 73 million Imperial gallons. The filtration plant as built would, therefore, be insufficient for the present requirements of the city, and either it would have to be worked much above its normal capacity or a mixture of filtered and unfiltered water would have to be used. Both conditions are undesirable, and such a situation should be avoided.

Bridges.—Under the present plans it is contemplated to build eleven bridges over the tailrace and canal, *viz.*:—

	Name.	Location.		Name.	Location.
1.	Wellington	Tailrace	7.	Asylum	Sta. 124.75
2.	Buffalo	Tailrace	8.	Crawford	Sta. 135.50
3.	Filtration	Sta. 14.00	9.	Knox	Sta. 190.10
4.	Church	Sta. 41.80	10.	Latour	Sta. 231.60
5.	Woodland	Sta. 81.30	11.	Lasalle	Sta. 269.39
6.	Location not decided.				

The cost would be the same in all cases, except for Scheme 2, when the Wellington and Buffalo bridges would have to be longer owing to the widening of the tailrace.



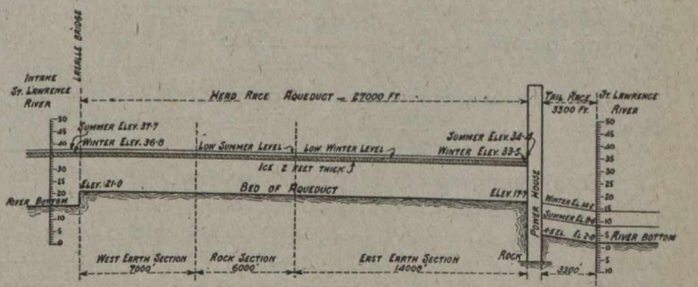
Scheme No. 2, Aqueduct Enlargement.

Gallery No. 1, Filtration Plant as it is built. Gallery No. 2, proposed extension for 100 M. I. G. Gallery No. 3, proposed extension for 150 M. I. G.

The head-gates of the canal are a part of the Lasalle bridge.

We have therefore left out the cost of 10 bridges in Schemes 1, 3, 4 and 5, but have included the cost of Lasalle bridge in all schemes. We have also added to Scheme 2 the cost of the Wellington and Buffalo bridges. Riprapping at other bridges than Lasalle may possibly be needed for all schemes, but its cost has been added to Scheme 2.

The riprapping we have figured upon, around the bridge piers in the canal, extends down stream for 100 feet from the head of the piers and for the whole width of the aqueduct. The bottom of the canal, where it is in earth, is excavated for a depth of 6 feet or to rock, if the rock is



Scheme No. 2, Aqueduct Enlargement.

less than 6 feet from the bottom of the canal. Five feet in depth is filled up with large and small stones and clay puddle, over which is laid one foot of good concrete.

Boulevards.—The cost of land for boulevards has been included only in Schemes 1 and 2. Owing to the grading of slopes in Schemes 3, 4 and 5, part of the land needed for boulevards is used for the banks, and the balance, becoming useless, has been omitted.

We cannot estimate in dollars and cents the value of the boulevards. Whatever value the boulevards may have to the city is beyond the scope of this report.

It must, therefore, be understood that there is no land for boulevards in Schemes 3, 4 and 5 and that in Schemes 1 and 2 we have included the cost of land for boulevards, and whatever grading and filling are included in Cook's contract and nothing else.

Contractors' Claims.—These being the same for all five cases, have not been included.

Frazil.—Messrs. Ernest Marceau and John Kennedy, in their report, dated May 6th, 1907, addressed to Mr. Frank Dowd, secretary of the water committee of the city of Montreal, say in their last paragraph:—

"The details of the works at the entrance of the aqueduct and the intake of the conduit are not yet fully worked out, but from the fact that the position of the present aqueduct intake is a very favorable one, and that no trouble has ever been experienced from frazil entering it, we are of the opinion that the works can be so designed and built, that their operation will not be seriously interfered with by frazil."

Mr. F. Clifford Smith, in his official history, "The Montreal Water Works, 1913," page 35, quotes Messrs. J. H. Harrington and Thos. L. Hickey, as follows:

"We have given considerable attention to the question of whether or not the frazil or slush ice would make any complications as regards the entrance of the river water through submerged ports, protected by wooden slats or screens. A considerable number of personal observations by Messrs. Janin and Lesage have been made by holding a screen in the water in this vicinity at times when frazil is known to occur at other places. Available data indicate the comparative absence of complications as to frazil. In recommending the construction of an intake 1,200 feet from shore, we beg to state that we have considered this matter with respect to the purification of the supply. Taking everything into consideration, we are convinced, as above stated, that it will be wise to carry out Mr. Janin's recommendations for the outer intake."

The ratepaying engineers, in their report of 1916, paragraph 7, say:—

"Serious operating troubles, due to frazil and other ice, are inevitable. These will greatly reduce the maximum output below 7,000 horse-power and may cause complete stoppage of the plant during a more or less protracted period every winter."

These opinions are from high authorities who are better acquainted than we are with the conditions at the entrance of the aqueduct.

The engineers who have studied and recommended the enlargement of the aqueduct have provided for a long extension of the cribwork at the entrance, to prevent the formation and admission of frazil. We have omitted the cost of this cribwork, as it may be built after the works have been in operation and conditions studied.

It is certain that frazil and anchor ice will give trouble, and to the best of our knowledge there is no way to prevent same. We have, therefore, provided for an auxiliary steam plant to furnish power during times of ice trouble. For the purpose of estimating, we have assumed that on the average there will be a decrease in hydraulic power equivalent to a complete shut-down of 2.4 months each year.

Dredging.—Any dredging needed for Schemes 1, 2 and 3, at outlet of tailrace, has been provided for in our estimates.

Consumption of Water by City.—The average quantities per day of water pumped during the years 1903-1913 are shown on the table at the top of the next page. The percentage of increases are also shown.

Present and Future Power Required for Pumping and Lighting by City of Montreal

Power actually used by city, pumping 60 million Imperial gallons per day, and for lighting.

Description.	Pump'g.	Light'g.	Totals.
Pumping, Atwater Avenue ...	4,710	....	....
Filtration, Atwater Avenue ...	2,960	....	....
Total	7,670	....	....
Electric pumps	2,000	....	....
Total for water supply ...	9,670	....	....
Sewers	520	....	....
Total pumping for city of Montreal	10,190	....	....
Lighting city	....	2,890	....
Total pumping & lighting	....	....	13,080
Montreal W. & P. Co. System	5,600	....	....
Outremont, Westmount, Maisonneuve, Verdun	....	1,064	....
Total for pumping city and Montreal W. & P. Co. systems	15,790	....	15,790
Total for lighting	....	3,954	3,954
Total horse-power	....	....	19,744
			say, 20,000 h.p.

Power needed in near future, pumping 100 million Imperial gallons per day, and for lighting.

Description.	Pump'g.	Light'g.	Totals.
Pumping, Atwater Avenue ...	8,570	....	....
Filtration, Atwater Avenue ...	3,270	....	....
Total	11,840	....	....
Electric pumps	2,500	....	....
Total for water supply...	14,340	....	....
Sewers	520	....	....
Total pumping for city of Montreal	14,860	....	....
Lighting city	....	4,330	....
Total pumping & lighting	....	....	19,190
Montreal W. & P. Co. System	8,960	....	....
Outremont, Westmount, Maisonneuve, Verdun	....	1,600	....
Total for pumping city and Montreal W. & P. Co. systems	23,820	....	23,820
Total for lighting	....	5,930	5,930
Total horse-power	....	....	29,750
			say, 30,000 h.p.

Table Showing Increases in Consumption of Water at Montreal

Year.	Million Imp. gals.	Percentage of increase.
1903	24.5	
1904	27.7	13.0% over 1903
1905	30.1	9.0% " 1904
1906	31.7	5.5% " 1905
1907	34.0	7.2% " 1906
1908	35.7	5.0% " 1907
1909	36.7	5.5% " 1908
1910	38.6	5.2% " 1909
1911	42.8	10.9% " 1910
1912	47.3	10.5% " 1911
1913	52.0	9.5% " 1912

In 1916 the average quantity of water pumped per day was 54,625,462 Imperial gallons. The percentage of increase in the water consumption between 1903 and 1913 is 112%, and the percentage between 1904 and 1913 is 88%.

Our calculations are based on an increase of 86% above the quantity of water pumped last year, and we have estimated that such an increase will take place in from 5 to 10 years.

It is this increased quantity we have called the "future needs of the city."

Power Actually Used for Pumping and Lighting and Future Requirements.—From the information we have been able to obtain, we give, in the tables at the bottom of page 454, the amount of power actually used for pumping and lighting by the city and the adjacent municipalities of Outremont, Westmount, Maisonneuve and Verdun, including the power needed for the filtration plant as now built.

Considering the rate of increase in the consumption of power which has taken place during the last ten years, we have also estimated the probable needs of the city and adjacent municipalities for the near future, say, within the next five or ten years. This is also in the statement below. It will be seen that the city and surrounding municipalities mentioned above, now use practically 20,000 h.p. for pumping and lighting, and that the requirements for the near future will not be less than 30,000 h.p.

Definition of the Term "Horse-power."—To avoid misconception of the term "horse-power" in our report, the letters h.p. represent the horse-power or energy due to falling water without any losses.

As this water passes through turbines and puts machinery in motion, to be transformed into electrical energy and sent over distribution lines to do useful work, some of the original energy is lost step by step, and all our calculations are based on the following table of efficiencies in horse-power for pumping and lighting.

The electrical horse-power available at the power house, or delivered according to present contract at 2,200 volts, will be indicated by e.h.p., and for the power delivered at other places, the name of the place will precede the letters h.p. and e.h.p. (See tables of efficiencies at the bottom of this page.)

Project as Designed.—We are indebted to the chief engineer of the city and his staff for copies of all documents and hydraulic data bearing on the Montreal aqueduct. These studies are exceedingly well made and have been found to be correct in agreement with assumptions made.

We cannot consider, however, as permissible, the high velocities assumed for the headrace, and we differ somewhat as to the co-efficient for retardation of flow due to the character of the canal bottom, factors which affect the quantity of power to be derived from the development.

In the information given it is stated that the flow in the canal has been obtained by means of the Kutter formula, assuming a slope of 3.3 in 27,000 feet, and a value of 0.02 for the co-efficient "n" (earthen channel in good order). The same co-efficient of 0.02 has evidently been assumed for the upper surface of the water when covered with surface ice.

Tables Showing Lighting and Pumping Efficiencies in Percentages of Water Horse-Power

LIGHTING.

Item.	Efficiency.	Overall efficiency.
Power at fall	100%	100%
Turbine	82%	82%
Generator	93%	76.26%
Outgoing lines	98%	74.73, say 75%
Lines to central distributing station	91%	68%
Rectifier	92%	62.6, say 62%
Line	96.8%	60.6, say 60%
Switchboard, power house to lamp	$\frac{60.6\%}{74.73}$	= 81%
Switchboard, main distributing station to lamp	$\frac{60.6\%}{68\%}$	= 89%

Efficiencies differ according to the machinery employed to transform the energy of falling water, and the above table is given only to show the value of the efficiencies which we have used in our calculations.

PUMPING.

Low Level Pumping, Atwater Avenue.

Power house switchboard	75%	
Motors	90%	67.5%
Pumps	80%	54%
Filtration plant, efficiency transformer and line	96% × 75%	72%

High Level Pump Efficiency, McTavish Reservoir. Smaller Units.

Motor and pump	68.8%, say 69%
Efficiency at switchboard	68% 47%

Papineau Avenue Pump Efficiency.

Motor and pumps	64.4%
Efficiency at switchboard	68%, say 44%

From this table it follows that:—

To produce:	Requires:
1 e.h.p.	1⅓ h.p.
1 lamp h.p., 746 watts	1⅔ h.p.
1 pump h.p. at Atwater Avenue	1.85 h.p. or 1.39 e.h.p.
1 pump h.p. at McTavish Res'voir	2.13 h.p. or 1.60 e.h.p.
1 pump h.p. at Papineau Avenue	2.28 h.p. or 1.71 e.h.p.

The ratepaying engineers, we are informed, assumed a higher co-efficient of roughness for their calculations of flow, and adopted a value of $n = 0.03$ as more correct, in their opinion, to meet the conditions of the canal, particularly that section which is in the rock cut, the effect being to give somewhat lower values in flow capacity.

After having given consideration to all the conditions affecting this factor, and examined the bottom and sides of the canal, we have come to the conclusion that co-efficient $n = 0.025$ is best suited to the conditions of the canal.

The canal is assumed to be covered with two feet of ice for winter conditions. It is also assumed that the hydraulic gradient is parallel to the bed of the canal, making the depth of water uniform; in other words, the difference in level or friction head between the entrance of the canal and the forebay, *viz.*, 3.3 feet, is totally absorbed in cases of maximum flow to produce motion or induce the water to flow in the canal.

When the turbines, however, take only a percentage of the natural flow, then only a percentage of the total friction head is absorbed.

Probably one of the most critical questions to be considered, which affects mostly, in this case, the amount of energy to be obtained from the development, is the question of permissible velocities as governed by the character of the bottom and sides in both the headrace and tailrace.

We are informed that the tailrace will be paved, thus permitting of velocities as high as 8 or 10 feet per second (5.46 to 6.82 miles per hour).

The bed of the headrace, for a large proportion of its length, is of such a character as will permit only of a very low flow velocity, in order to prevent scour and danger to the walls. On this account we have looked with particular care into the question of limiting velocities for the project as designed.

Velocities.—The principal elements of a water power development are, the sectional area of the power canal, the permissible velocity of flow due to the material through which the canal is built so as to prevent all danger of scouring, the amount of water available and the net head.

For the project under execution we may say that the supply of water is practically unlimited. The section of the headrace or canal may be said to be fixed; that is, it cannot be further enlarged without great and unreasonable cost, on account of the large percentage of the side-walls already built, and it must remain the governing factor as to amount of water available to produce power, assuming an adequate enlargement of the tailrace where no work has yet been done.

The capacity of the canal is, in turn, necessarily dependent on the maximum velocity which can be permitted on the earth bottom sections of the canal, side concrete walls being provided under existing contracts.

We have given the most serious consideration to this question, and comparative studies have been made to determine the resulting flow and power, considering the nature of the material forming the bottom of the present canal, and also a concrete paved bottom.

Taking first the case of development under the present plans, we find the following reference to the nature of the material, in the report dated February 21st, 1914, of Messrs. J. A. Jamieson, R. S. Lea and G. R. Heckle, on the Montreal water supply conduit:—

The soil through which the aqueduct is being excavated, and in which the conduit is embedded for the greater part of its length, is largely composed of boulder

(Continued on page 470.)

MONTREAL WATER AND POWER COMPANY'S CHLORINE CELL INSTALLATION.*

By Frank Henry Pitcher, M.A.Sc.,
General Manager, Montreal Water & Power Co.
and James O. Meadows, A.M.Can.Soc.C.E.,
Chief Chemist, Montreal Water & Power Co.

THE sterilization of public water supplies with chlorine or chlorine compounds, either as an adjunct of filtration or as a sole method of purification, is now standard practice and this method is well understood, but the production of electrolytic chlorine and the application of the gas so produced to the water to be purified, is of rather recent date, and except in a general way is but little understood by the waterworks fraternity.

The electrolytic cell installation of the Montreal Water & Power Co. has been in service since the first part of the present year, a period hardly long enough from which to gather average operating results, but during the time that the plant has been in service considerable information and data has been secured that is of interest.

Historical Sketch.—The fact that the common salt can be broken down or decomposed into its elements, sodium and chlorine, by electrolysis, has been known practically since the discovery of the galvanic cell, but the commercial application of this principal was impossible until many difficulties had to be overcome to perfect an electrolyzing equipment which would efficiently and effectually separate the products and at the same time withstand the corrosive action of the chlorine gas.

Numerous types of electrolytic cells, or decomposing chambers, have been evolved and perfected to a degree, but only a few have been even a partial success commercially.

In its simplest form an electrolytic cell is a tank or chamber, composed of materials that will resist chlorine, and containing brine in which a positive and negative electrode is immersed. Upon the passage of an electric current through the cell, chlorine gas is liberated at the positive electrode, or the anode, and simultaneously metallic sodium is released at the negative electrode, or the cathode. This metallic sodium immediately combines with the water in the brine, forming caustic soda, and liberating hydrogen gas. The momentary products from the cell are, therefore, chlorine gas, a weak caustic solution, and hydrogen gas: but the chlorine gas and the caustic soda immediately combine to form sodium hypochlorite, or so-called sodium bleach.

Cells of exactly the type described have been and are now sold for laundry use, but they cannot be employed when a complete separation of the products is required. Furthermore, this type of cell can produce only a weak bleaching solution, and that inefficiently, because after the sodium hypochlorite reaches a certain strength, it is in turn decomposed by the electric current, making the process retroactive, with the damaging result that the oxygen in the sodium hypochlorite combines with the carbon of the anodes to form carbon dioxide gas.

From the foregoing it is obvious that to obtain a perfect cell for the production of chlorine gas, the chlorine and the caustic soda, which are the primary products of electrolysis, must be prevented from recombining. To

*Paper read before American Waterworks Association, May, 1917.

secure this separation of the products, four distinct lines of development have been followed:—

(1) By the insertion of a permeable diaphram between the anode and the cathode.

(2) By employing a mercury cathode which is alternately the cathode in the electrolyzing compartment of the cell and the anode in an adjoining compartment where the amalgam of metallic sodium and mercury is decomposed by water.

(3) By placing the cathode under the anode and depending upon the stratification of the electrolyte which occurs due to the different densities of the brine solution and the caustic solution surrounding the immersed cathode.

(4) By the use of a fused salt electrolyte and a molten lead cathode.

Only the diaphram and the mercury types survived commercial exploitation in this country on account of the inefficiency and cost of maintenance for the other types indicated above under items three and four.

The several forms of diaphram cells which have been commercially operated, consist of two groups:—

(*a*) Cells with submerged diaphrams and cathodes.

(*b*) Cells in which the electrolyte comes in contact with one face only of an unsubmerged diaphram.

Very early in the history of electrolysis, Le Sueur, Gibbs, Crocker, Nelson and others conceived and operated cells of the submerged diaphram, or first group. Le Sueur employed a horizontal diaphram and Gibbs employed a circular cell with a vertical diaphram.

The unsubmerged diaphram group is in turn subdivided into two classes,—with permeable and impermeable diaphrams.

All of the permeable diaphrams for both the unsubmerged and the submerged group of cells are composed of asbestos paper or cloth, disposed in the cell in such a manner that they separate it into two distinct compartments, designated (1) as the anode compartment, into which the saturated brine is introduced and where the chlorine is formed; and (2) the cathode compartment, where the caustic soda is formed.

With cells of the submerged diaphram group it is possible to a large extent to keep the chlorine gas and the caustic soda separated by maintaining a liquor level in the anode compartment higher than the level in the cathode compartment, thus inducing a continuous flow from the anode to the cathode chambers. Nevertheless, by osmotic action and mechanical interchange through the diaphram, the salt caustic liquor from the cathode compartments invades the anode compartment and there combines with the chlorine to form sodium hypochlorite, which results in the loss of these two products and causes a rapid disintegration of the anode, as previously noted in the description of the laundry cell.

Cells of the submerged diaphram type operate in practical service at not more than eighty-five per cent. current efficiency (excepting only the Billiter-Siemens cell), with a maintenance which is in direct ratio to their lack of efficiency; because, the less efficient the cell, the more hypochlorite is formed in the anode compartment, with the consequent shortening of the life of the anodes.

Cells of the submerged diaphram type operate with reasonable efficiency during the first few weeks of service after a new diaphram has been inserted, but as the age of the diaphram increases, it becomes less permeable and accordingly more effective as an osmotic vehicle for the contamination of the anode by the products of the cathode compartments.

With cells of the second group, having the diaphram immersed on one side only, the above-described contaminating influences are entirely eliminated, because there is no large body of caustic liquor present in the cathode compartments, since the cathode liquor is withdrawn as fast as it is formed. It follows that in actual service cells of this type closely approximate theoretical current efficiency, with a resulting increased output and a longer life than can possibly be attained by cells of the submerged diaphram type.

The Allen-Moore cell, as installed by the Montreal Water & Power Co., is of the unsubmerged diaphram type and is guaranteed to have a current efficiency of not less than ninty-two per cent.

Description of the Installation.—The chlorine cell installation consists of a salt storage bin (having a capacity of 40 tons of salt), the brine saturating and purifying equipment, two 15-h.p. motor generator sets, four chlorine cells and the silver ejectors and distributing lines for applying the chlorine water to the water to be treated.

The brine saturating and purifying equipment consists of three vertical galvanized iron saturators (twenty-seven inches in diameter by six and a half feet in height, provided with a spray system at the bottom and an outlet six inches from the top), and two concrete reaction tanks having a capacity of 82 cubic feet each. These tanks are built with sloping bottoms and are provided with a pipe grid for air agitation. Two sand filters are provided for filtering the purified brine which passes from the filters to the two concrete storage tanks, having a capacity of 276 cubic feet each.

The distributing lines for applying the chlorine water to the water to be treated are one-inch chemical hose lines, and the chlorine gas is ejected into the water by means of a silver ejector, which maintains a four-inch vacuum on the chlorine cells and takes the gas from the chlorine main through the ejector to the distributing lines.

Description of Chlorine Cell.—The four electrolytic cells are of the Allen-Moore type. Each cell is a standard 600-ampere unit and is 7 feet long by 20⅜ inches wide. Each cell is provided with Acheson graphite anode plates, and pure wrought iron perforated cathode plates. As stated previously, the Allen-Moore cell is of the unsubmerged diaphram type and uses asbestos paper for the diaphram material. Unlike several other types of electrolytic chlorine cells, the cell box of the Allen-Moore cell is made of concrete, properly protected at the surface to withstand the action of the chemicals.

The cells are connected in series and are provided with short-circuit switches or cut-outs. The voltage carried on each cell is approximately 3.3 volts, and each cell is capable of producing 32 pounds of chlorine per 24 hours.

Preparation of Brine Solution.—A small quantity of water under pressure is allowed to flow in the bottom of the saturators. The saturators being charged with salt, a saturated solution of salt is delivered to the two concrete reaction tanks. A sufficient quantity of soda ash is added to the brine in the reaction tanks to combine with the calcium and magnesium salts present in the brine, and the contents of the tanks are agitated for one-half hour to insure complete mixing of the soda ash solution with the brine, and also to hasten the reaction. The solution is then allowed to remain in a quiescent state for one hour to allow the precipitate formed to settle, when the solution is filtered through the sand filters into the purified brine storage tanks. A sample of the purified brine is

taken and titrated for residual alkalinity, which determines the amount of hydrochlorite acid necessary to add to neutralize the alkalinity and leave a residual acidity of about .01 per cent. It is necessary to have the electrolyte slightly acid to prevent the formation of hypochlorites within the cell, and the subsequent loss of cell efficiency.

Electrolytic Cell Efficiency.—The cell or current efficiency is computed from the cell flow of caustic liquor, the amount of caustic produced, and the current used to effect the dissociation. The flow of caustic liquor is measured for a certain period and computed as liters flow per hour, and at the same time a portion of the caustic liquor is titrated with normal acid to determine its strength. Knowing the flow per hour and the amount of caustic per litre, the number of grams of NaOH produced per hour can be easily determined, which figure is known as the actual caustic production.

The number of amperes passing through the cell, multiplied by 1.49 grams (theoretical NaOH production per hour per ampere) will give the theoretical caustic production; and this result, when used as the divisor, and the actual caustic production as the numerator, will give a product which when multiplied by 100 will be the percentage current efficiency of the cell. Also, as the amount of caustic produced is to the amount of chlorine produced as the atomic weight of NaOH is to the atomic weight of chlorine, the amount of chlorine produce can be easily determined. The amount of chlorine produced can also be determined by direct titration, and this chlorine assay will act as a check on the first determination. The operating current efficiency has so far been maintained at between 93 per cent. and 96 per cent.

Cost of Chlorine Production.—The annual cost of production is arrived at as follows:—

Salt @ $8 per ton	$ 500.00
Power @ $30 per h.p.	450.00
Interest at 6 per cent. on $5,000	300.00
Depreciation at 15 per cent.	750.00
Labor and superintendence	500.00
Total	$2,500.00

Three out of the four chlorine cells furnish the requisite amount of chlorine for sterilization, yielding 90 pounds of chlorine gas per 24 hours, or 32,850 pounds per year, making the cost of chlorine produced 7.6 cents per pound.

Comparison with Present Hypochlorite Cost.—The annual cost of sterilization previous to the installation of the chlorine cells was as follows:—

Chloride of lime at 3.75 cents per lb.	$4,105.00
Interest at 6 per cent.	150.00
Depreciation at 5 per cent.	125.00
Labor and superintendence	500.00
Total	$4,880.00

As the amount of chloride of lime required was 300 lbs. per day, or 100 lbs. of available chlorine, the cost per pound was 13.4 cents, or 5.8 cents per pound more than chlorine produced by the electrolytic cells.

With normal market conditions the annual cost of the two forms of treatment would be approximately the same, if one did not consider the general depreciation that chloride of lime causes about a water purification plant.

Operation of Chlorine Cells.—An electrolytic chlorine cell functions at its best when under a constant current load, and for this reason it is good practice not to vary the load; or, if varied, to bring about the change gradually. Variations in load cause a considerable deterioration of the diaphrams, with a consequent loss in cell efficiency. For this reason automatic control of the chlorine production from an electrolytic cell is not practical, and for the treatment of a large volume of water, without appreciable variations in volume, automatic control is not required, for the dosage can be regulated for the maximum requirements without causing tastes or odors during the minimum consumption periods. The three cells required to supply the chlorine consumed for sterilization are operated with a current load of 500 amperes and 13 volts. The electrolytic cells require very little attention, and to date have given excellent satisfaction.

Caustic Liquor.—The caustic liquor from the cells contains about 12 per cent. of sodium chloride and about 10 per cent. of NaOH. No recovery of the salt and caustic is attempted, because the amounts of these two chemicals produced is so relatively small that their recovery would not be economical. For large installations the recovery of the salt and caustic is a regular feature of the process, the salt recovered being used over again, and the caustic is concentrated and sold as liquid caustic.

Reasons for Adoption.—The chlorine cell installation was adopted because of the saving effected over the present high price of chloride of lime, because of inability to secure this chemical with any degree of certainty, and also because common salt is very much easier to handle around a water purification plant, and its use in the chlorine cells does not cause the general deterioration about the works that the use of chloride of lime does. Over-dosage with chlorine does not cause the trouble that chloride of lime over-dosage does, because odors and tastes are not present to the same degree.

The short experience at Montreal with chlorine cells for the sterilization of a public water supply, indicates that an installation of this kind is perfectly feasible for large water supplies where the cost of power is not excessive.

SECURED B.A.Sc. DEGREE.

As a result of the recent examinations of the School of Practical Science, Toronto, the following gentlemen may now write "B.A.Sc." after their names:—

Harold A. Babcock, Joseph Banigan, Albert E. Berry, Robert S. C. Bothwell, Frank C. Christie, James C. Colleran, Ellis H. Corman, John Van E. Dickson, Jonathan A. Fraser, William K. Greatrex, George Hanmer, Alfred B. Harris, Ralph W. Harris, Richard W. Hurlburt, Ludovic Levesque, Stewart G. McCandlish, Harold L. McClelland, Patrick E. McIlhargey, Ralph C. Manning, Alvan S. Mathers, John E. O'Brien, William A. R. Offerhaus, Harry A. Parr, Roswell D. Ratz, Ernest E. Smith, Arthur M. Snider, Rupert M. Speirs, Albert W. Swan, Arthur P. Thomson, Charles E. Tilston, Benjamin C. Tomlinson, Victor Topping, Alexander A. Tufford, Howell A. Tuttle, Edward J. Tyrrell, Harold R. Watson and George Wood.

The Canadian Electrical Association will hold a convention of all the members of the association at the Ritz-Carlton Hotel, Montreal, on June 7th and 8th. Secretary, Alan Sullivan.

Letters to the Editor

Railway Valuation Costs.

Sir,—I note in your issue of the 10th inst. a reference to the cost of valuations, in which you state that my recent work for the Commission of Inquiry into Railways and Transportation in Canada cost $3 per mile, which "compares with $240 per mile for the Interstate Commerce Commission's valuation of United States railroads, with $40 per mile for Prof. Swain's valuation of the New York Central Lines, and with $50 to $100 per mile for other valuations which have been made by him."

In order that there may be no misapprehension on the part of your readers, let me state that my report gave no figures with reference to cost of valuations. The cost of my work in Canada is, however, accurately stated by you.

Various estimates have been made of the cost of the valuation of United States railroads by the Interstate Commerce Commission, and one recent estimate, including the cost to the railroads, was at the rate of about $240 per mile. This estimate, however, may prove to be much exaggerated, as nobody knows as yet what the total cost will be, and I need not say that I, of course, assume no responsibility for it.

So far as I am informed, some other valuations of railroad properties have cost up to $75 or $100 per mile, but I have not authoritatively verified these figures, nor have I made any valuation of large properties myself which have cost over $50 per mile.

We should not prejudice the work of the Interstate Commerce Commission by publicly stating figures which may prove to be much exaggerated. The work of that commission, of course, is being done in great detail. Whether such great detail will result in greater accuracy of the final figure, considering the many inherent uncertainties in the problem, may be a question. I have in my library, for instance, reports on valuations in which the inventories are given in such detail that there are many items of $.01. Of course, in any valuation, it is a question how far the detail work should be carried, and there may be differing opinions as to this matter.

GEO. F. SWAIN, LL.D.

Cambridge, Mass., May 18th, 1917.

Montreal Paving Report.

Sir,—I note in your May 10th issue a review of our recent report on paving, made to the chief engineer of Montreal. It seems to us that the last paragraph, unintentionally we are sure, gives a somewhat erroneous impression of some points in the report. You say:—

"The report contains approximately fifteen thousand words and is very exhaustive, reviewing the whole field and offering a considerable number of valuable constructive criticisms, although there are some recommendations with which all engineers would not agree, particularly the recommendation that one type of pavement be adopted as the standard throughout the whole city, the statement that certain pavements previously laid in Montreal could not have proven economical 'had they lasted forever without repair or renewal,' and the recommendations regarding omission of the binder course."

It might be pointed out that our recommendation is that a "standard" be adopted and generally used, except in such places where specific reasons exist for departing from that standard; heavy traffic grades, too steep grades, railway special work, around watering troughs, etc. We believe that engineers have nearly all reached the conclusion that a city's paving map should not resemble a crazy-quilt, with several types of paving being laid under the same general conditions, when it can certainly, at this late date, be determined which of the several is the best for a certain condition in a certain city. In fact, I do not think it was ever the engineers that were responsible for our crazy-quilt paving maps; these are the work of the politician and his good friend, the pavement promoter.

You seem to doubt that certain pavements cannot have proved economical on certain streets "had they lasted forever without repair or renewal." If you were bankers instead of engineers, I am sure you would not disagree with me on that point. The annual interest on the original cost of some pavements, alone, is more than the interest on the original cost plus the full maintenance and renewal costs of other pavements on streets where the traffic does not justify the heavy original expenditure. If you will consult your copy of "Paving Economy," especially the chapters relating to permanency cost, the average annual cost, and elimination process table, I think you will change your opinion in this matter.

Regarding the recommendation that the so-called binder course be omitted, you are, of course, quite right in stating that all engineers would not agree on this point. I am aware that most engineers, and some of the best asphalt specialists in the country,—the others but following their lead,—do recommend the so-called binder course. My experience has been such, however, that I am compelled to take an independent stand on this point, in spite of the fact that I am well acquainted with and have personally discussed the matter with all the most noteworthy advocates of the binder course. A recent experience in Toronto, when Mr. Powell took me over a street the pavement of which he said was nine years old and consisted of a four-inch concrete foundation and a two-inch asphaltic surface, without binder course, did not shake my conviction very much, for the street is in excellent condition.

When I eliminated the so-called binder course in Milwaukee in 1910, there was much comment in the daily papers. The usual remark was that we were departing from the recognized practice, and that the new pavements would not be as good as the old ones. It was customary to refer with pride to an asphalt surface on Jefferson Street, in front of the Hotel Pfister, as an example of the old construction that was exceptionally good; it being the first asphalt surface laid in the city, and about twenty years old at the time. It occurred to me to dig up a section of this pavement, as I had certain suspicions. It had no binder course. I looked up the contract; and no binder course was mentioned therein. In fact, as I had supposed, the binder course had not reached Milwaukee in those days. The old cushion coat was provided, which is merely a laying of the regular asphalt mixture, with slight variations, in two courses. An unnecessary expense that has been abandoned.

The binder course has for some time been a bone of much contention; but, when considered in conjunction with some other paving matters that should be discussed more freely, it is relatively unimportant. A pavement well laid, either with or without the binder course, will, of course, give excellent service; and its use or elimination is largely a matter of securing the best construction and at the least ultimate cost.

C. A. MULLEN,

Director of Paving Dept., Milton-Hersey Co., Ltd.,

Montreal, May 19th, 1917.

The Engineer's Library

Any book reviewed in these columns may be obtained through the Book Department of The Canadian Engineer, 62 Church Street, Toronto.

CONTENTS.

BOOK REVIEWS.

The Flying Machine from an Engineering Standpoint. By F. W. Lanchester, M.Inst.C.E., M.Inst.A.E., Member of Advisory Committee for Aeronautics. Published by Constable & Co., London, 1916. 135 pages, illustrated, 5½ x 8¾ ins., cloth. Price, $1.50. (Reviewed by J. H. Parkin, Mechanical Engineering Department, University of Toronto.)

The book is a revised reprint of the 1914 "James Forrest" lecture before the Institute of Civil Engineers, which appeared in serial form in "Engineering" in May, 1914. The work forms a brief treatment of the technical aspects of flight and the aeroplane as viewed by the aeronautical engineer and constructor, and the treatment is clear and concise.

The flying machine is compared with other means of locomotion, such as the locomotive or motor car and its comparative advantages and disadvantages in this respect pointed out. The air is considered as the track on which the aeroplane travels, the various theoretical paths or phugoids being briefly examined and the serious "Catastrophic Instability" touched on. The various elements making up the coefficient of traction of the machine, including the direct and aerodynamic resistance of the aerofoil and the body resistance are then dealt with under the "Laws of Resistance." The different factors influencing these are enumerated, their relative importance shown, and the close agreement between theoretical deductions, by the author and others, and experimental data on resistance illustrated. At high speeds the total resistance is shown to be made up largely of body resistance emphasizing the importance of the stream line (ichthyoid) form. Propulsion, with a brief discussion of the propeller, is next considered, followed by a note on the power installation and the interrelation of engine and propeller.

A more extended discussion of the detailed construction of the aeroplane is then given, including brief outlines of the factors governing the design of the aerofoil, resistance of struts and wires, the effect of vertical surfaces (the wheels and propeller have a marked effect in this respect), factor of safety, and landing gear, land and marine. The work on stability is chiefly an outline of the situation as to the literature of the subject.

There follow four appendices and a reprint of a paper, "A Discussion of the Theory of Sustentation and the Expenditure of Power in Flight," which deals with the more controversial points of aerodynamics and was prepared by the author for the International Engineering Congress of 1915.

The author's high position in the mathematical and technical branches of aeronautics and his previous publications on the subject guarantee the worth of the present volume and while none of the sections have been treated in an exhaustive manner, the principal points have been indicated and their bearing on this phase of the subject. The book will not be found easy reading by those not versed in the subject of aeronautics as considerable initial acquaintance with the science is assumed and frequent references are made to the author's previous work, "Aerial Flight (2 vols., 1908, London). The book forms a concise and able summary of the state of scientific aerodynamic knowledge and the technical art of aeroplane construction at the time of the delivery of the lecture in May, 1914.

Advertising and Its Mental Laws. By Henry Foster Adams, Instructor in Psychology, University of Michigan. Published by The Macmillan Co. of Canada, Limited, Toronto. 329 pages, 23 illustrations and numerous tables, 5 x 7½ ins., cloth. Price, $1.50 net.

An interesting study of the psychology of advertising for the advertising man and for the student, containing, in addition to the theoretical material, much experimental data.

The basic principles of psychology which are related to advertising, and their application, are clearly presented. The complexity of an advertisement is reduced to its elements, to show with mathematical exactness the effect of the various elements. The results of laboratory experiments are compared with results of actual advertising campaigns, showing the strikingly close relationship between the business and the theoretical tests.

The author analyses action, showing why advertisements lack in effectiveness, and indicates devices which will improve pulling power.

This treatise is a valuable addition to advertising literature, and one of the most practical and thorough books ever published on the subject. Its study will unquestionably be of great benefit to every advertising man and to every business man who advertises.

English and Engineering. By Prof. Frank Aydelotte. Published by the McGraw-Hill Book Co., Inc., New York. 390 pages, 5 x 7½ ins., cloth. Price, $1.50 net. (Reviewed by R. O. Wynne-Roberts, Toronto.)

The perusal of this volume of essays by writers of international fame has afforded the reviewer a degree of pleasure not often enjoyed. Mr. Aydelotte is the professor of English in the Massachusetts Institute of Technology and his object in making the selections is to help students to express themselves in writing and speaking, not merely grammatically but with order, force, sincerity and such

charms as their natures will allow. And also to show that the function of English is to furnish something of the liberal, humanizing and broadening element which is more and more felt to be a necessary part of an engineering education. The engineer is destined to play an important part in the drama of national life and must therefore be prepared to undertake his share of duties and responsibilities. The engineer, then, "must speak in terms of civilization, in human terms as well as material, or be a traitor to his opportunities." The introduction to this book is worth a careful perusal, for it contains many thoughts expressed in simple yet eloquent phrases.

The book contains excellent essays on Writing and Thinking, The Engineering Profession, Aims of Engineering Profession, Pure Science and Applied, Science and Literature, Literature and Life. One of the essays was written by Mr. John Lyle Harrington, who was educated at McGill University, Montreal. He contends that language is the engineer's most important tool and it therefore behoves him to see that it is always in good order. "It is because engineers are so little accustomed to order their thoughts and language properly that they have so little part in the business and correspondence of the corporations which employ them." This is a grave statement to make, but those who listen, observe and think will regretfully acknowledge that there is considerable truth in the assertion. "A technical man is, presumably, an educated man; and if he does not speak like one, suspicion is cast upon the entire range of his learning."—"Language has large weight in classifying a man infinitely more than manners or dress."—"The preparation of reports, specifications and contracts is the most particular and momentuous task the technical man has to perform."—"Probably the majority of the civil lawsuits are caused not by trickery or deceit or dishonesty but by the use of ambiguous words and phrases, bad ordering of the matter, incompleteness and other faults in the language of the correspondence, specifications and contracts." Such are a few of the observations made by Mr. Harrington.

Dr. Mann states that nearly one-third of the answers to enquiries made by the Joint Committee on Engineering Education complain of the engineer's inability to express himself well in speech and writing.

The reviewer had previously read the late George S. Morrison's book titled "The New Epoch," and without doubt it should be read by all engineering students. Three of Morrison's essays are presented here. One of his epigrammatical observations is as follows: The engineer "is the priest of material development, of the work which enables other men to enjoy the fruit of the great sources of power in nature and of the power of mind over matter. He is the priest of the new epoch, a priest without superstitions." An essay by General Francis A. Walker, a graduate of Amherst, also should be of special interest to Canadians. He states that the student's success in life and in his professional and social position largely depends upon the manner in which his work is done in college. He argues that "all that can be asked in regard to any school is that there shall be zeal in study, delight in discovery, fidelity to the truth as it is discerned, high aims and ambitions which have not sole or primary respect to material rewards." Such a standard is a magnificent one to attain, and requires the services of men of fine qualities to maintain.

Prof. Haultain has often publicly emphasized that the most important function of an engineer is to be useful to the community and in this regard he has the endorsement of General Walker—"to become an useful man, well-equipped for life, capable of doing good work, respected and entitled to respect," should be some of the attributes of an engineer.

The other writers of the essays are such men as John Ruskin, Arnold Bennett, Frederic Harrison, George Henry Lewes, John Butler Johnson, Thomas Henry Huxley, John Tyndall, John Henry Newman, Matthew Arnold, William Wordsworth, William P. Atkinson, Robert Louis Stevenson, Ralph Waldo Emerson and Thomas Carlyle. Stevenson's essay on "The Influence of Books," is excellent; in fact, all of the essays are excellent, but some are more easily assimilated by the reader.

This volume should not only be on the engineer's shelf, but frequently read, for by repeated perusals and study we may acquire an adequate diction to clothe the skeleton thoughts we desire to express.

Instructions to Locating Engineers and Field Parties. By F. Lavis, M.Am.Soc.C.E. Published by the McGraw-Hill Book Co., Inc., New York. 44 pages, 10 folding maps and charts, 6 x 9 ins., cloth. Price, $1.00. (Reviewed by James H. Kennedy, M.Can.Soc.C.E., Vancouver, B.C.)

This work is designed to fill a long-felt want, as there has not been any work published on this subject confined exclusively to just what is necessary to this class of work, though there are several larger works that give instruction along this line, together with other matters. I thing it will become quite popular with the younger locating engineers especially. The work bears the earmarks of an author who has had experience in the field in which he writes. The instructions given for carrying on survey work are in accordance with the best up-to-date practice for large undertakings, and no doubt are intended to be varied somewhat for smaller undertakings and local conditions, that will be apparent to the man in charge.

In regard to the keeping of field notes the author gives excellent advice; and he might have gone further and advised the instrumentman that no company will keep a man on the payroll for the purpose of an expert to interpret his own notes, and no instrumentman who does not keep his note book properly indexed, dated, etc., up-to-date as the work proceeds, should be allowed on such work.

The lists of equipment, supplies, etc., are very full and complete and will be found a very great help to engineers outfitting for work. There are many engineers, who are masters of the situation when locating work is in progress, but find great difficulty in making the proper lists of supplies for camp outfit and provisions.

The work should be in the stationery box of every locating engineer when he leaves the head office, and for distribution in Canada it is to be hoped the author may add a page giving the requirements of the Railway Commission regarding preparation of plans and profiles.

Manual of Reinforced Concrete. By Marsh and Dunn. Published by Constable & Company, London, 1916. 475 pages, 101 illustrations, 4¼ x 6½ ins., leatherette. Price, $3.00. (Reviewed by Peter Gillespie, C.E., University of Toronto.)

The third edition of Marsh and Dunn's Manual of Reinforced Concrete has recently come to hand. The authors, in rewriting the volume, have introduced much new material and incidentally omitted some matter included in previous editions, in order to keep the book within reasonable limits. The work is largely a compilation from a great multitude of sources, the publications of the British and American engineering organizations and the technical press of both the old world and the new

being frequently quoted. The notation employed is the standard adopted some years ago by the Concrete Institute of London and other influential British organizations and to one accustomed to the symbols now so generally employed by writers on this side of the Atlantic, a little difficulty in reading results. One cannot but feel that the usefulness of this excellent reference book to American readers will be sensibly reduced because of the use of an unfamiliar notation.

The first 113 pages of the volume are devoted to matter descriptive of materials and of construction methods. Then follows some 300 pages which are given over to theoretical matter, the first third of which is a discussion of the mechanics of beams, slabs and columns; and the remainder of which consists of the application of these principles to the design of a multitude of structures comprising apparently nearly everything to which reinforced concrete as a structural material can lend itself. Specific computations are facilitated in actual design by a large number of inserted graphs or charts covering beams, columns and T-beams, from which the busy designer can readily obtain much of the information he desires. It is interesting to observe that in the discussion of the stability of retaining walls, the theorem of Professor Rankine is easily given the first place. Indeed, the influence of that illustrious writer whose works have held for over two generations a unique and respected place in the literature of engineering, is plainly evident in many places throughout the book. The treatment of continuous beams is much more complete than is ordinarily found in American text books. The concrete truss without diagonals is briefly considered. To the flat slab, here designated the "mushroom" floor, several pages of discussion are devoted and the computations for a four-way floor of assumed span and loading are worked out in detail after a method generally attributed to Mr. A. R. Lord. The regulations of the city of Chicago governing this now popular type of construction as adopted some two years ago, are included. The computation of reinforced concrete beam deflection receives a brief consideration. The discussion of the retaining wall seems quite complete, and includes the full computations for a wall with counterforts for assumed conditions. The reinforced concrete arch of several types is treated according to the semi-graphical method. Other sections are devoted to coal bunkers, chimneys and dams. The final chapter is given over to practical geometry, tables of areas, metrical equivalents, properties of rolled shapes, etc., of much the same character as is found in the ordinary handbook.

The volume seems to have been compiled with a proper regard to arrangement and continuity and because of the scope of the subjects included, should become a valuable addition to the designer's library.

Preliminary Mathematics. By Prof. F. E. Austin, E.E., Hanover, N.H. Published by the author. First edition, 1917. 169 pages, 4¾ x 7¾ ins., cloth. Price, $1.25. (Reviewed by Alfred S. L. Barnes, Hydro-Electric Power Commission of Ontario.)

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being frequently quoted. The notation employed is the standard adopted some years ago by the Concrete Institute of London and other influential British organizations and to one accustomed to the symbols now so generally employed by writers on this side of the Atlantic, a little difficulty in reading results. One cannot but feel that the usefulness of this excellent reference book to American readers will be sensibly reduced because of the use of an unfamiliar notation.

The first 113 pages of the volume are devoted to matter descriptive of materials and of construction methods. Then follows some 300 pages which are given over to theoretical matter, the first third of which is a discussion of the mechanics of beams, slabs and columns; and the remainder of which consists of the application of these principles to the design of a multitude of structures comprising apparently nearly everything to which reinforced concrete as a structural material can lend itself. Specific computations are facilitated in actual design by a large number of inserted graphs or charts covering beams, columns and T-beams, from which the busy designer can readily obtain much of the information he desires. It is interesting to observe that in the discussion of the stability of retaining walls, the theorem of Professor Rankine is easily given the first place. Indeed, the influence of that illustrious writer whose works have held for over two generations a unique and respected place in the literature of engineering, is plainly evident in many places throughout the book. The treatment of continuous beams is much more complete than is ordinarily found in American text books. The concrete truss without diagonals is briefly considered. To the flat slab, here designated the "mushroom" floor, several pages of discussion are devoted and the computations for a four-way floor of assumed span and loading are worked out in detail after a method generally attributed to Mr. A. R. Lord. The regulations of the city of Chicago governing this now popular type of construction as adopted some two years ago, are included. The computation of reinforced concrete beam deflection receives a brief consideration. The discussion of the retaining wall seems quite complete, and includes the full computations for a wall with counterforts for assumed conditions. The reinforced concrete arch of several types is treated according to the semi-graphical method. Other sections are devoted to coal bunkers, chimneys and dams. The final chapter is given over to practical geometry, tables of areas, metrical equivalents, properties of rolled shapes, etc., of much the same character as is found in the ordinary handbook.

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Nationalization Would Add Billion to Country's Debt*

So Says the Minority Report Presented by the Chairman of the Railway Inquiry Commission—Opposes Drayton-Acworth Recommendations—Advises Continuation of Public Aid to Canada's Railroads

By ALBERT HOLLAND SMITH
President, New York Central Lines

THE Canadian Pacific is amply able to take care of itself. It can and does provide competition with the other railroads. In order to be most serviceable to Canada, it should be continued, subject only to such equitable regulation as is accorded to all lines.

The Grand Trunk succeeded in the east and failed in the west. The Canadian Northern succeeded in the west and was jeopardized by its eastern expansion.

There is extensive duplication of lines in the west; the unsuccessful Grand Trunk Pacific lines are found among the successful Canadian Northern lines. Public policy demands the unification of these lines, for great economies could be thereby accomplished.

There is extensive duplication in the East; the new Canadian Northern lines among the older lines of the Grand Trunk proper. Great economies in proposed investment and operating expenses await the joint working of these properties.

There is wasteful duplication in the connecting region between North Bay and Winnipeg, where the Canadian Northern line parallels the government line. Economy awaits the joint working of these lines.

Remedies Recommended.

Consideration of all phases of the problem leads me to recommend the following remedies for the existing situation: Let the Canadian Pacific alone; let the Grand Trunk operate the eastern lines now held by that company and the Canadian Northern; let the Canadian Northern operate the western lines now held by that company and the Grand Trunk Pacific system; let the government operate the connections or procure their operation by private companies; all of which should be done under arrangements that are equitable, and yet look to the not distant day when the country will have survived the war and resumed its prosperous growth.

There may be several ways by which this can be brought about, but the one that has appealed to me is that which seems to be the least disturbing of values and credit and involves no untried schemes or protracted disputes. Therefore, I beg to make the following suggestions:—

1. Amend the regulating policy so that the Railway Commission may have jurisdiction over all railroads in the matter of maximum and minimum rates, the issuance of securities, the building of new railways, or the extension of lines, and other matters properly within the scope of governmental supervision.

2. Create a board of trustees, consisting of two government officials and three private citizens, to act for the government in the matters hereinafter proposed.

Relieve the Grand Trunk.

3. Relieve the Grand Trunk Railway Company of its obligation to lease the Transcontinental, and require the company to relinquish all claims upon the Transcontinental; require it to lease to the Board of Trustees the Grand Trunk Pacific railroad properties at a rental amounting to the net annual fixed charges; require it also to take under lease the Canadian Northern properties east of North Bay and Parry Sound, and pay as a rental the net fixed charges on those properties. The time of the lease should be for twenty-one years. The Grand Trunk's investments, other than railroad, in the West may be disposed of by the company as it may elect, and in accordance with its best interests.

4. Require the Canadian Northern Railway Company to confine its operation to the field west of Winnipeg. Relieve it of the line east of Winnipeg by leasing for twenty-one years to the governmental Board of Trustees at a rental of the net annual fixed charges. Require it to take a lease of, and to operate for the same period the Grand Trunk Pacific Railway, and its branch lines, paying as rental the net annual fixed charges upon those properties; except that until seven years after the end of the war they shall have the immunity that was promised the Grand Trunk Pacific for a period of seven years after construction, and that they shall not be required to assume any of the extraneous investments of the Grand Trunk System in the West.

Twenty-one Years' Lease.

5. Lease the lines between North Bay and Winnipeg (except the Canadian Pacific's) for a term of twenty-one years to either the Canadian Northern or the Grand Trunk (or, in event neither applies, to any other qualified company), requiring the lessee to furnish the necessary capital for new equipment, and to maintain and operate the lines on the best terms that can be made; terms that would give the best service needed at lowest cost to the government being regarded as best. Either the government or the lessee should build a connecting line of about thirty miles near Long Lake, Ontario, to protect the better working of the two lines.

6. The government and companies should have the option of terminating, after ten years, any of the leases upon equitable terms.

The foregoing recommendations are made with a view to obtaining for Canada a maximum of efficiency at a minimum outlay. The continuance of government aid, to some of the railroads at least, will be necessary under any plan. The plan herein proposed seeks to reduce this to the lowest possible point and to centralize it upon those parts of the existing lines which are not self-supporting, and which, in the nature of things, cannot be self-supporting for years. These connecting links, "bridges," as they have been called, exist, it seems to me, as a result of that public policy which has been discussed at some length. The government may well afford to take them over and maintain them as necessary parts of the public investment in the country's development. They are not of sufficient importance to bring about those dangers inherent in government operation of this kind on a large scale, and holding them will not endanger private enterprise. It may be necessary in working out this plan to grant some additional and temporary aid to the Canadian Northern, and it will be necessary to effect some compromise with the Grand Trunk Railway Company which will enable this company to continue. Aid should be extended upon the recommendation of the Board of Trustees, who should be charged with the duty of investigating the need of and approving the aid to be rendered by the government; they should also see that the government receives for that aid such security as will give it a reversion in case of default.

Fair Solution of Problem.

The recommendations here submitted are to be considered as a general outline of what appears to be a fair solution of the transportation problem. Enabling legislation will be required in any case, and I realize that there are many technical and legal questions which will require careful attention at expert hands. If the general plan is adopted, my thought is that the Board of Trustees which I have suggested be charged with the duty of acting for the government in all matters requiring new contracts, and shall protect the interest of the government in every way while leasing, operating, or financing the property under their care to the best advantage, due consideration being given to the rights of the other parties at interest.

If for any reason it should prove inexpedient to carry out the foregoing suggestions, and if the government should find it wise or necessary to possess itself of, and to hold any considerable part of the railway properties, I should recommend as an alternative plan the formation of a private company to

*Abstracted from minority report of Royal Commission to Enquire into Railways and Transportation in Canada.

take over other operations of those properties, either as a whole or in groups. Even where a road does not earn its fixed charges, the government could profit in the long run by making the terms of an operating lease sufficiently attractive to induce private enterprise to undertake its management. The terms of the contracts would naturally depend upon the extent of the property and the prospect of earnings, but they could be so drawn as to prove attractive to private capital and at the same time relieve the government of the expense and embarrassment of government operation. Such contracts might be based upon a profit-sharing plan on a fair basis, which would leave the company a hope of reward commensurate with its efforts, and give the public also a share in the prosperity which they must help to create.

Desperate Need of Equipment.

I should like to add one other thought. The railways of Canada are in desperate need of equipment. Whatever decision is made with reference to the railways, the transportation problem is now acute in so far as equipment is concerned. I would, therefore, recommend that the government undertake at once to provide an ample supply of freight cars and locomotives against immediate and imperative needs. These cars and engines may be had, if desired, under trust agreements. It will be a simple matter to turn these cars and engines over to the operating companies under lease or contract of purchase, which may be exercised when conditions are more nearly normal.

Concluding, I would be loath to suggest recourse to any radical changes in the domestic policy of the Dominion of Canada in this time of war and stress. Remedial measures are often more efficacious than revolutionary ones, and more equitable. I have been impressed by the seriousness of your transportation problem, and in sincerity express my belief that the problem can be successfully and satisfactorily remedied by just and mutual recognition of difficulties and full and free co-operation between the government and the railroads. Fair and broad treatment of the question will, I am convinced, bring capital and personal genius commensurate with the exigencies of the present situation, and capable of developing a happy solution. I believe that the best results hitherto have been obtained by the efficiency and economy of private initiative, energy, and capital. It is no longer assumed that the self-interest of the railroad investor and operator is antagonistic to the interest of the public; rather, we have all learned, governments and corporations alike, that the two are inseparably linked and must stand or fall together. Upon these fundamental truths I base my firm conviction that the brightest outlook for the future of your great Dominion can be assured through the extension of private railroad enterprises. The hope of honor and the reward of public approval must be open to human kind to get the best results from human endeavor.

Facing the urgency of the need, considering the part which the government has taken and the responsibility which it shares, and keenly alive to the magnitude and the importance of the tasks now placed upon the railroads and the greater tasks which they will face, I see no safe alternative but the government shall continue, with discrimination and resort to all available safeguards, and under a policy of proper regulation and co-operation of effort, to aid the necessitous railroads of the Dominion until such time, which I hope and believe will not be far distant, when these will become self-supporting and the problem will be solved.

Extensive Re-Organization Unnecessary.

We are asked to make suggestions in regard to "the reorganization of any of the said railway systems or the acquisition thereof by the State; and in the latter case, the most effective system of operation, whether in conjunction with the Intercolonial Railway or otherwise."

The first practical question is, therefore, the need of reorganization of any of these three transcontinental systems; the second is whether they should be acquired by the State; and the third is whether the status of the Intercolonial can be changed; and, if so, can the road be advantageously grouped with either of the three systems.

In such suggestions as I shall make, I am influenced by consideration of the public policy as evidenced by past governmental acts. I further assume that the existence of these roads through the direct aid and sanction of government is conclusive evidence of the fact that the people really desire them. That they were built in advance of their need for ordinary commercial uses—a fact which is emphasized by the present abnormal economic situation—does not appear to me a sufficient reason for condemning the policy of national development, or the wisdom and integrity of those who have built the roads under that policy. Neither do I think that there exists any condition to warrant taking up a new and untried public policy, which may lead to greater difficulties than those which are now faced.

The history and standing of the Canadian Pacific Railway, and its public service as a carrier to-day is sufficient assurance that it does not need reorganization. The scope of its business, extending to other lands by steamships and commercial connections, and the control of many thousand miles of railroads in the United States, would afford sufficient reasons, if none other existed, for dismissing the idea of its acquisition by the State.

So much of the Intercolonial as is serviceable to the Canadian Pacific appears to be now used by it, either as a local connection or through trackage rights. Moreover, the two have existed separately for many years as competitors, and no new reason appears why the relations of the Intercolonial and Canadian Pacific should be changed for the future, unless the people of Canada are satisfied that better results would be obtained for the territory served by the Intercolonial if it were in the hands of the Canadian Pacific.

C.T.R. Cannot Carry Obligations.

The Grand Trunk Railway Company has stated that it is beyond its power to assume and carry the obligations which would be imposed upon it if it should try to become such a transcontinental system as the plans of 1903 contemplated. The company has not attempted to bring about the organization of a system approximating that of the Canadian Pacific, or even the Canadian Northern, nor can it do so.

In view of the parent company's inability to carry out its original plans, and to discharge its obligation, the question is, what disposition is to be made of the various roads which were intended to be, but did not become, parts of one operating system?

My colleagues have recommended that the stockholders of the Grand Trunk Railway Company be paid an annuity, which is to be a "moderate but substantial portion of $3,600,000, the average dividend payment for the last ten years." This recommendation is in spite of the facts noted in the report that there are arrears in maintenance which require the expenditure of twenty-one millions of dollars, and that the company has charged to capital items which should properly have been charged against income, these facts indicating that there have been some dividends paid which have not been earned. Considering this situation, and also the obligation of the company in the West, I am not impressed with the justice of paying an annuity to the stockholders in exchange for a surrender of this property. I also would be liberal to them, but I would allow them to keep their property and give them a chance to work out their own salvation. To that end, I would recommend that a settlement be effected between the government and the Grand Trunk Railway Company. The railway cannot carry out its part of the contracts, and it should be relieved of further embarrassment. On the other hand, the stockholders of the Grand Trunk Railway should be required to curtail or forego their dividends for the present, and the entire earnings be applied to the rehabilitation of the road through a term of years. The government thus gives up a present claim which the debtor cannot pay anyway; in turn, it will enjoy improved and extended service, which may be worth far more to the welfare of the people. I should also give the government some claim upon the future earnings of the Grand Trunk, so that it may share in any future prosperity which this action makes possible.

Put Itself Into Shape.

Reorganization of the Grand Trunk is desirable only in so far as it shall be required to put itself in shape to discharge efficiently its functions as a carrier. Whether it shall retain all of the subsidiaries which it has accumulated through the past fifty years depends in large measure on what they can contribute to the main property. Careful study of each of the subsidiaries will lead to definite conclusions from the standpoint of the Grand Trunk and its future welfare.

What the Grand Trunk needs most of all is to be relieved upon equitable terms of the embarrassment that it has incurred through the failure of the transcontinental scheme. The acquisition by the State of the Grand Trunk Railway proper presents much of the embarrassment that would obtain in the effort to acquire the Canadian Pacific, for here also, in addition to the question of equity involved, there is

the problem of some two thousands miles of railroad owned in the United States; and the fact that the Grand Trunk's principal seaport is in the United States.

The investigation of the Canadian Northern by the Commission has disclosed evidence of skill in construction and efficiency in management, considering the means and equipment available. The company even now earns a large part of its fixed charges, although important parts of the system have been in operation for but a year. I think there is ample justification for confidence that the affairs of the company will improve with the return of normal conditions. I see no reason for a change of management or a reorganization, excepting as hereinafter suggested.

Relation of Intercolonial.

It may be well here to consider the relation of the Intercolonial to the other roads, and the possibility of operating it in conjunction with any of them. We have shown its relation to the Canadian Pacific. The main line of the Intercolonial is about 1,000 miles, from Montreal to Halifax. It has occupied the territory for fifty years and has become adapted to it. There are apparently no operating economies available by combining it with another system that are not available to it alone. Assuming proper regulation, there appears to be no traffic interchange that could be better assured by merger. I am informed that the Maritime Provinces consider the use of the Intercolonial as a right to which they are entitled. Moreover, the government has built the Transcontinental, a part of which was in compliance with plans of the Grand Trunk, while the rest of it is so placed that it ought to continue to be operated in conjunction with the Intercolonial. The present status of the Intercolonial and the eastern part of the Transcontinental should be continued as a government operation. The results of such operation should, however, be reported to the people of Canada in exactly the same form as is required from other railroads. And these roads should be subject to the same reasonable regulation as is exercised over all other railroads.

Mention might be made here of the railroad that the government is building from the Saskatchewan River to Hudson Bay. The object in the construction of this road has been stated to be that of obtaining a shorter haul from the western provinces to Europe. The bulk of the traffic to follow this route must necessarily be diverted from the roads extending from Winnipeg to the East, so that the project seems to be an instance of competitive construction, which cannot be justified in this case, even on the ground that it opens up new territory.

There are numerous local railway projects, within provincial limits, which at the moment seem to have little effect upon this general railroad problem. Disposition of these may well await developments as to their necessity and utility when they assume operation. There is little that can be said just now as to their probable relation to the existing means of transportation.

Natural Route to East.

The Great Lakes and the St. Lawrence River furnish a natural route from the western country to the East, and to the Atlantic ocean for a part of the year. Numerous steamship lines between Port Arthur and Georgian Bay or the lower lakes and St. Lawrence River ports afford adequate transportation under normal conditions, though somewhat affected by customs requirements and other factors. In view of the heavy movement of grain in the last three months of navigation, regulations governing shipping should be as favorable as practicable, for the hauling of grain over the long distances to the eastern seaboard by an all-rail route involves a problem in car supply and cost which renders such a haul unprofitable for rail lines.

The success of the Canadian Pacific steamship lines has led to the suggestion by some that the other railroads ought also to establish steamship lines. I do not believe that this success was primarily due to the railroad ownership of the ships. Temporarily, the war seems to have put a stop to plans for railroad-owned steamships. If, at the close of the war, it is to be tried again, it would seem advisable first to ascertain whether other ships cannot be induced to schedule sailings before railroads incur the responsibility of making additional investment in ships. There are ships running in regular postal routes with subventions. Perhaps the government might well require, in connection with its subventions, that ships give equal service to the railroads without discrimination among them, thus removng another cause for the employment of duplicate facilities.

In visiting the various ports, I was impressed with the facilities installed and being installed. At Halifax, particularly, important works were actively under way, necessitated I believe, by the overseas traffic for war purposes. It is likely that the future development of steamship terminals in connection with railroads will be difficult to fix until normal conditions resume. Meanwhile, the Atlantic seaports are so much involved in the emergencies of war as to place them beyond the scope of this inquiry. In any event, such works of harbor improvement and development as are the result of war measures will be there at the close of the war as a foundation for what the future may hold.

Unable to Join Colleagues.

I am unable to join my colleagues in their recommendations. They propose that practically all of the railways in Canada, except the Canadian Pacific and the American lines shall be turned over to a corporation to be managed by a board of trustees appointed by government. They insist that this board is to be permanent and self-perpetuating. I do not know by what means one parliament can bind its successors to a given policy, especially in so simple a matter as changing the organization of a government board. My friends seek to avoid government ownership and operation, in fact, condemn it as inadvisable, but propose a plan which contains so many elements of danger in the direction which is sought to be avoided that I am unable to join them.

Their plan would add about a billion dollars to the direct debt of Canada. The interest on this is about forty millions, adding very largely to government expenses. Judging from the experience Canada has had with its government railways, it is fair to assume that this would remain a permanent burden. Operated by private companies, this interest would ultimately be borne by the companies without recourse to the government funds, and at the same cost of service to railway patrons as would obtain under government operation.

Their plan also leaves out some of the railways. This is unfair to the investors whose property is to be subjected to government competition. It also discriminates in the method by which the respective properties are to be acquired. I cannot approve the proposed centralization of control. There are problems local to separate regions which often require prompt action and co-operation between the railroads and the people served. There is a need everywhere for that prompt and efficient service which can come only from a knowledge of local conditions and responsibility for meeting them. I cannot believe that centralization, remote responsibility and control, will ensure good service to the people of Canada.

Fundamental Defect of Plan.

The recommendation creates a Dominion Railways Company, owned by the Dominion government, to take over those roads. There are about 7,000 miles in the United States controlled by Canadian companies. The Canadian railways depend for no inconsiderable portion of their revenue on United States traffic. A fundamental defect of the plan, therefore, is in placing the government in the railroad business, not only in Canada, but also in operating railroads in the United States subject to both federal and state regulation.

Through private railway management, Canada has obtained about one mile of railroad for each $30,000 of government aid of guarantees, which is but a fraction of the cost of government railroad undertakings. In some instances, a large proportion of the aid was in land, the value of which was produced by the building of the railroad and the settlement thereby made possible. Compared with the total outlay involved in producing railroads by the government for itself, as, for instance, the case of the Intercolonial or the Transcontinental, from three to six times that amount have been used to realize equal results. This shows distinctly the value of enlisting and retaining private enterprise.

ONTARIO SUES ELECTRICAL DEVELOPMENT CO.

Attorney-General Lucas, of the province of Ontario, has issued a writ on behalf of the Commissioners of the Queen Victoria Park, against the Electrical Development Co., claiming $225,665 under an agreement, dated January, 1903, between the Park Commission and Sir Wm. Mackenzie, Sir Henry Pellatt and the Hon. Col. Frederic Nicholls. Damages are for the value of power said to be developed by the defendants in excess of the amount which they were licensed to develop. Also an injunction is applied for to prevent the company from making any further excess development.

DIVERSITY OF PATENT LAWS

Patent law in the British Empire is discussed in the recent report made by the Dominions Royal Commission. In the United Kingdom anyone who imports an invention from abroad, provided that it is not in use in the United Kingdom, may obtain a patent, but any hardship that might arise from this provision is modified by the adherence of the United Kingdom to the International Convention for the protection of industrial property, under which an inventor in any country adhering to that convention is allowed priority over other applicants during a period of one year from the date of his foreign patent. Australia and New Zealand expressly refuse protection to imported inventions. The United Kingdom and most of the dominions admit to protection the assignee or legal representative of an inventor, but in Newfoundland only the assignee is given protection, and then subject to conditions.

The report says:—"There is divergence as to opposition to the grant of patents. Newfoundland provides no machinery for this. Canada allows opposition only in case of conflicting applications. In the United Kingdom, Australia, and the Union of South Africa, there are many and different grounds, and in New Zealand there are no limitations to the grounds of opposition.

Life of Patent.

"In Canada the life of a patent is 18 years, in the United Kingdom and all the other Dominions 14 years. The provisions for, and periods of, renewal differ widely.

"In the United Kingdom a patent may be revoked after four years for non-working. This provision was complained of in evidence before us in London, and the complaints were supported both in New Zealand and Australia. In Canada and Newfoundland a patent is void after two years if not worked, whilst Canada has also a provision under which a patent is voided if the patented article is imported into the Dominion by the patentee after the expiration of one year (subject to extension) from the date of its grant. In Australia and New Zealand, if working is not satisfactory, the court may by order allow a patent to be worked by others than the patentee but without revocation. In the Union of South Africa revocation in consequence of non-working is allowed after three years.

"The United Kingdom, Canada, Australia, New Zealand, and the Union of South Africa make provision for the grant of compulsory licenses by the patentee if the competent government authority is not satisfied with his working; Newfoundland makes no such provision.

As to Fees.

"Witnesses in the United Kingdom dwelt strongly on the question of fees and the heavy cost of full protection. This cost was set down in 1912 at £289 for the United Kingdom and all the Dominions, but has since been reduced to £166 by recent legislation in the Union of South Africa. Even so, the case is not so bad as these figures would make it appear, because the total sum is only payable when an inventor wishes to protect his invention throughout the self-governing parts of the Empire for the full life of the patent. What an inventor needs most is protection from the dangers of early publicity, and he can obtain provisional protection in the United Kingdom and all the Dominions for a much lower sum.

"The laws of Australia and New Zealand already resemble those of the mother country in essentials with regard both to provisional and complete specifications whilst the recent legislation of the Union of South Africa is also similar to that of the United Kingdom. Canada does not appear to contemplate provisional specifications, but allows the intending applicant for a patent who has not perfected his invention to file a description of his invention so far as it has proceeded and this filed document (called a 'caveat') gives him protection for one year. Newfoundland does not provide for provisional specification or caveat, but gives protection for six months from the date of delivery of specification.

"In view of the divergences between existing legislation, some of which, but by no means all, we have sketched above, and of the number of legislative authorities amongst whom agreement would need to be sought, immediate uniformity seems impossible. It has been suggested to us by witnesses that, if an invention has been patented in any of the self-governing parts of the Empire, it should be patentable in all parts on payment of search fees, but the fees payable for full protection are now so low that there would be no practical gain in the adoption of this suggestion.

"In the United Kingdom the renewal fees are heavy, but, as was pointed out to us in evidence, it is only reasonable that a patentee should pay more heavily for the continued right to exploit a market of 45 million persons than for that of exploiting the smaller markets of the Dominions.

"We do not think that the question of fees is one in which reform is most urgently required. There are others on which action is more needed, and also immediately practicable. These we may classify as follows:—(1) The legislation now in force in Newfoundland is somewhat out of date and could be remodelled with advantage. We hope that the necessary steps may be taken. (2) Efforts should be made to arrive at uniformity in the United Kingdom and all the Dominions with regard to compulsory licenses and revocation for non-working.

"In our judgment the Australian and New Zealand system, which we have described above, is the most satisfactory. This system should be combined with clauses for compulsory licenses.

Uniformity Without New Legislation.

"(3) Even without new legislation it should be possible to secure complete uniformity in the mother country and the self-governing dominions in regard to:—(a) the forms that have to be filled in when a patent is applied for; (b) the declaration to be appended to those forms; (c) the specifications and drawings required; (d) the amount of protection obtained by acceptance of provisional specifications. Much useless expense and trouble would be saved by uniformity in these respects. (4) Legislation is desirable to secure uniform duration of patents."

STEEL NOT AVAILABLE FOR SHIPS

Canada will not be in a position to build steel ships for at least two or three years. This was a statement of Mr. Mark Workman, president of the Dominion Steel Corporation, at Montreal. He added that scarcity of steel was the chief cause.

The entire output of steel from the Dominion Steel Corporation's plant had been contracted for by the Munitions Board up to the middle of 1918, and the chances were that this contract would run into 1919.

Some criticism has been directed at the officials of the corporation because of the sale of a ship plate mill some months ago to United States interests. Mr. Workman, when asked regarding this, explained that the plant sold was incomplete, and that it would be impossible to make ship plates from it.

No Raw Material.

He pointed out that he thought it had been purchased some seventeen years ago, had never been operated nor installed. He added that a plant properly equipped to manufacture ship plates would require an expenditure of something like $2,500,000, and the plant sold had been purchased for $70,000.

Going further into the prospects of steel shipbuilding here, Mr. Workman said that it would be an absolute impossibility for the Steel Corporation to operate a plate mill at the present time, even if they had one on the ground, because of their inability to secure raw materials. The corporation has a rail mill lying idle because sufficient ore cannot be obtained to operate it.

Extensions Cost $5,000,000.

"The Canadian Government Railways, the Canadian Pacific and the Grand Trunk are all crying bitterly for rails, but we can do nothing to help them as shell requirements just about exhaust our product," he said.

To increase the steel output they would have to start at the ore output from the mines. Additional furnaces would have to be installed, as well as new coke ovens. Work is at present well advanced on these extensions, and the corporation is spending this year something like $5,000,000 in extensions and improvements at Sydney, but this increased output is all provided for in contracts already made with the Munitions Board.

"These extensions will require a great deal of additional labor and it will be another question whether we can secure this or not," he concluded.

Shipyards are Busy.

Sir George Foster in a statement in parliament last week said:—

"Every shipyard in the Dominion of Canada which is able to build ships and is equipped therefor has not only the opportunity but has the actual contracts for building every

ship and every vessel they can turn out, and today the building of vessels in this country for the specific purpose of warding off and fighting the submarine peril is being carried on in all the shipyards. And in regard to the building of wooden ships an arrangement has been completed and is being carried out whereby anybody or any company that can undertake to build wooden ships and complete them within a certain time will get an opportunity to do so and will be assured that over and above the cost of building the ships they will have a reasonable profit guaranteed to them."

EDMONTON'S PUBLIC UTILITIES.

A. G. Harrison, city commissioner of Edmonton, Alta., forwards to *The Canadian Engineer* a statement of the results of operation of the public utilities of the city of Edmonton for the year 1916. This statement shows a surplus over all charges, including depreciation, of $64,788 on electric lighting and power, $24,410 on waterworks, $9,570 on telephones, and $39,430 on power-house (up to June 30th, 1916), making a total surplus of $138,198. This is reduced however, to a surplus of $18,601 on account of the deficit of the street railway, which amounted to $119,597. Mr. Harrison calls attention to the fact that a sinking fund has been maintained to retire the debentures. The street railway is earning 4⅓ per cent. on the capital invested, and shows a betterment of more than $16,000 over the year 1915.

ROAD AID IN SASKATCHEWAN.

H. S. Carpenter, deputy minister of highways of the province of Saskatchewan, has informed the secretary-treasurers of all rural municipalities in his province of the passing by the legislature of an Act which grants not less than $300 and not more than $600 per annum to each rural municipality for the purpose of assisting in the maintenance and improvement of main roads leading to market towns. The total of such grants paid in any year is not to exceed 80 per cent. of the net revenue received during the previous fiscal year from the fees for automobile licenses. Annual report is to be made to the department as to how the money has been spent.

AMERICAN SOCIETY FOR TESTING MATERIALS.

The twentieth annual meeting of the American Society for Testing Materials will be held June 26th-29th at Atlantic City, N.J. There are to be eight technical sessions, one to be devoted to each of the following eight subjects: (1) Tests and testing, (2) Steel and iron, (3) Non-ferrous metals, (4) Preservative coatings and miscellaneous materials, (5) Cement and concrete, (6) Concrete and lime, (7) Ceramics, (8) Miscellaneous materials. A session will also be devoted to the annual address of the president, and there will also be an organization session, at which reports of committees will be received, election of officers announced, and miscellaneous business conducted.

CREDIT DUE INTERNATIONAL NICKEL.

"Credit should be given where due," says the May Bulletin of the Canadian Mining Institute, "and credit certainly attaches to the International Nickel Corporation for the exercise of a very commendable restraint in maintaining, until within a few weeks ago, the price of nickel at the pre-war figure, notwithstanding that the increased cost of production would have quite warranted an advance in the price of the metal, and that at a time when the demand was abnormally great. Had the corporation taken advantage of the opportunity that offered, it might have increased its profits enormously at the expense, mainly, of Britain and her Allies. Had the International Nickel Corporation happened to be a Canadian concern its policy in this respect would have been acclaimed as a most praiseworthy example of practical patriotism. At any rate, the course it has pursued is in very striking contrast to the greed displayed by some Canadian war profiteers."

AMERICAN PAPERS ON RAILWAY REPORT.

Some of the American engineering papers have expressed editorial views upon the reports submitted by the Canadian Railway Commission. The "Railway Age Gazette" holds the opinion that the Drayton-Acworth plan "would not serve the double purpose for which apparently it is put forward—that of avoiding the dangers incident to government management in a democratic country, and at the same time secure the advantages that are usually conferred by private management."

"While the Drayton-Acworth plan has much merit," continues that journal, "there is great force in some of the criticisms which Mr. Smith makes upon it. Is it not a fact, as he suggests, that a board of trustees created by one parliament may be abolished by a later parliament? A point of hardly less importance is as to how the proposed plan would assure efficiency in management. The first board of trustees would be chosen by parliament. What assurance is there that parliament would select competent men? If the first team were not composed of competent men, those later elected to the board very probably would not be strong men, and who is to call the trustees to account if they do not do their work well?"

"Whichever recommendation may be the more sound," says the Engineering News-Record, "the point to be noted is that both are radical. Desperate cases require desperate methods—especially in war time. The dilemma of our northern neighbor is not without its warning to us. The day is long past when we will make wholesale donations to our railroads, nor are we likely to permit wild cat construction. It is not so certain that other circumstances, controllable or otherwise, may not bring some or all of our roads into equally serious difficulties. Railroads and the public are inseparably linked—at least, in bad fortune."

CAN. SOC. C.E. ELECTIONS AND TRANSFERS.

At a meeting of the council of the Canadian Society of Civil Engineers, held May 15th, the following elections and transfers took place:—

Member—Arthur C. Tagge, Westmount.

Associate Members—Frederick R. Adelhelm, Montreal; William A. Begg, Regina, Sask.; Patrick Burke-Gaffney, Winnipeg; Frank H. Farmer, Winnipeg; William P. Gross, New Westminster, B.C.; Harold G. Phillips, Regina; William C. Rowse, Winnipeg; and John Stewart, Cincinnati, Ohio.

Students—C. W. Boast, Montreal; F. D. Pringle, Hamilton.

Transferred from Associate Member to Member—Paul F. Mercier, Montreal; Thomas S. Scott, Kingston, Ont.

From Junior to Associate Member—Henry C. Craig, St. Catharines, Ont.; William E. Janney, Toronto; Frank S. Milligan, Toronto; Stanley D. Parker, Ottawa.

From Student to Junior—Robert C. McLachlan, Port Nelson, Man.

B.C. GOVERNMENT SUES P.G.E. RAILWAY.

Action against the Pacific Great Eastern Railway Company, the firm of Messrs. Foley, Welch and Stewart, the directors of the railway companies and subsidiary concerns and against the contractor, Mr. P. Welch, has been commenced by the British Columbia government.

As against Messrs. Foley, Welch and Stewart the province seeks judgment to compel them to carry out their personal covenant to build the railway line and telegraph line, repayment to the province of moneys paid by the province on account of the railway company, etc.

Against Messrs. Foley, Welch and Stewart, and also Messrs. Tate, White and Wilson is asked an order cancelling the $24,960,000 share capital of the Pacific Great Eastern Railway Company, and a declaration that each of the defendants were directly interested in contracts, and, therefore, disqualified to sit as directors.

The province also seeks a judgment that $12,500,000 of the share capital of the railway company is the property of the Crown in right of the province as security under the Loan Act, 1916.

Editorials

HEAVY EQUIPMENT EXPENDITURES.

One of the points upon which the majority and minority reports of the Railway Inquiry Commission agree is the immediate need of railroad equipment. Mr. A. H. Smith describes this need as "desperate" and says whatever decision is made with reference to the railways, the transportation problem is now acute in so far as equipment is concerned. He recommends that the government undertake at once to provide an ample supply of freight cars and locomotives against immediate and imperative needs. Sir Henry Drayton and Mr. Acworth say that to catch up arrears of maintenance in the case of the Grand Trunk property, $21,000,000 "must be spent immediately," and to prevent arrears again accumulating future maintenance charges must be much heavier than in the past—not less than $2,500,000 more annually, according to President Chamberlin's judgment, on equipment alone. New capital expenditure of over $30,000,000 is also immediately required. The Drayton-Acworth report states also that the Grand Trunk system immediately requires at least 200 more locomotives and 10,000 freight cars.

Among the deferred expenditures of the Grand Trunk Railway system are the following items: Rebuilding and reinforcing freight car equipment, $8,943,000; equipping freight and passenger cars and engines with safety appliances, $475,000; deferred renewals in maintenance of way department, $11,761,000. The cash expenditure on the single item of rails "required to restore normal conditions" on the Grand Trunk is reported as $5,312,000. It is, of course, to be borne in mind that a portion of these expenditures are fairly chargeable to capital account, as outlined by Mr. Chamberlin in his public statement which was reviewed last week in this column.

The Canadian Northern Railway must spend $84,000,000 on a five-year programme to put the road on a paying basis, according to a special report made on their behalf. The Drayton-Acworth report says that $40,000,000 for equipment and $30,000,000 for betterments would be a moderate estimate of the Canadian Northern System's need in the next five years, assuming that that road remains separate and independent.

According to a statement made by Senator Curry, president of the Canadian Car and Foundry Company, the Canadian railroads require about 40,000 cars to bring their equipment up to present requirements. Whatever is done to solve our railroad problem, very large expenditures are necessary for new equipment to give anything like an adequate freight service and at the same time maintain normal passenger service.

WATER FILTRATION IN CANADA.

A table purporting to show the number of filtration plants in the United States and Canada has been published by a number of American engineering and municipal papers, compiled from figures supplied by Burns & McDonnell, consulting engineers, of Kansas City, Mo. According to these tables, Canada is credited with 28 plants in the year 1916, whereas the Commission of Conservation of Canada, in its report on waterworks and sewerage systems, mentions 72 municipal filter plants in Canada in 1916. The provinces of Nova Scotia, Ontario and British Columbia are omitted entirely from the aforementioned table, while the figures for Alberta, Manitoba, Saskatchewan and Quebec are incorrect.

DIFFERENTIAL OCEAN FREIGHTS

Before the war, British steamship companies made a practice of charging a lower rate to New Zealand from Hamburg and other German ports than from London, on the same classes of goods. This facilitated the competition of German manufactures with British in New Zealand. It unduly handicapped British manufacturers and destroyed, at least to the extent of the difference in freight, the advantage intended by New Zealand to be given by means of preference to the British manufacturer. No assurance has been given that similar practices will not continue after the war. The case is much the same with regard to the differential freight rates charged, for example, on asbestos from Canada to foreign and British ports.

This matter of freight discrimination receives considerable attention in the reports of the Dominions Royal Commission, which heard many complaints of the kind during its tour of the British Empire. The commissioners, representing the United Kingdom, Canada, New Zealand, South Africa and Newfoundland, regard "as intolerable that British ship owners should be in a position to initiate or countenance practices of a kind so directly inimical to British trade." The commissioners state that the Imperial government has not yet been convinced of the necessity or, if convinced, has not yet found the time to take the matter in hand, in spite of the representations made by more than one Dominion government. "Our investigations," they say, "have satisfied us that in normal times the combination of shipowners is strong enough to limit the freedom of shippers, whose varied and detached interests make it difficult, if not impossible, for them to combine in any effective opposition, and that therefore, in principle, it is not desirable that the operations of the steamship companies should remain longer without some measure of government supervision."

To overcome these objections, the Commissioners recommend that the contractors for subsidized mail services should be required to submit a schedule of freight rates, both of import and export, for the approval of the governments concerned, the rates when approved, not to be altered without consent. Similar action is recommended in the case of vessels, to the construction or operation of which government contributions are made. It is also suggested that the Imperial and Dominion governments should establish inquiry boards to investigate complaints of shippers. The Commissioners express themselves strongly as to the differential freight rates, and propose that the suggested inquiry boards should have authority, at their discretion, to order the abolition of differential rates which were found inimical to Imperial trade.

PERSONALS.

ARTHUR A. COLE, president of the Canadian Mining Institute, is on a trip to the Pacific Coast for the purpose of aiding the Research Council in organizing the collection of industrial information. Mr. Cole is field organizer for the central joint committees that are assisting the Council.

Dr. HOWE, of the University of Toronto, with two technical assistants, will commence for the Commission of Conservation and in co-operation with the Laurentide Company, Limited, a survey of the cut-over pulpwood lands.

S. S. SCOVIL, B.Sc., formerly assistant chief engineer of the Manitoba Hydrometric Survey, and for the last two years engineer for the Dominion Technical Board in connection with the International Joint Commission, has been granted leave of absence to go overseas with the Pioneer Construction Battalion.

K. H. SMITH, engineer of the Nova Scotia Water Power Commission, is representing the commission in tests of some specially constructed turbines, manufactured in Pennsylvania.

WILLIAM YOUNG, chief comptroller of water rights of British Columbia, has been in Montreal and Ottawa conferring with the engineers of the Industrial Research Council.

MONTREAL AQUEDUCT ENLARGEMENT.

(Continued from page 456.)

clay or rock powder. When comparatively dry or well drained, it will stand in a bank with practically vertical face, but when fully saturated with water, tends to flow in a horizontal surface and is easily eroded and transported by running water. This latter property has a very direct bearing on the safety of the conduit, in view of the proximity of the aqueduct excavation.

The ratepaying engineers in a memorandum submitted to this board, under date of March 5th, 1917, referring to the canal section of the aqueduct, say:—

"Maximum permissible mean velocity, with material as found in earth section, shall not exceed 2.5 feet per second."

In a report made during 1894, Messrs. Keefer and Vanier, speaking of the tailrace, say:—

"The surface inclination of the water when delivering its full economical discharge with a velocity of 100 feet per minute, or a little over one mile per hour, will not be more than one-half that of the present aqueduct."

This is equivalent to a velocity of 1.65 feet per second (probably surface velocity) and would indicate that the surface velocity in the old aqueduct was as high as 3.33 feet per second (2.27 miles per hour), equivalent to a mean velocity of about 2.7 feet per second (1.84 miles per hour).

On the other hand, Mr. T. C. Keefer, in a report to the city of Montreal, dated December, 1886, gives the result of a few measurements of surface velocities made in August, 1884, which gives an average surface velocity of 1.70 feet per second (1.25 miles per hour), equivalent to a mean velocity of about 1.3 feet per second (0.89 miles per hour).

No accurate information is available as to whether erosion occurred at any time in the old aqueduct canal.

From specifications for contract No. 2 it would appear that it was anticipated that exceedingly soft material was likely to be encountered in some sections of the work, as paragraph 46 reads as follows:—

"In any case where, in the opinion of the engineer, exceedingly bad plastic or aqueous material is encountered in the bottom excavations of the canal, particularly between stations 45 and 90, and whenever this material (soft clay pockets, quick sand, loam, leaf mold or muck, etc.) is so soft or silty as to be improper to insure the required bearing power of the soil, the contractor shall be required to furnish and drive wooden piles to carry the footings * * * ."

Some of the best authorities on hydraulics give figures for the allowable velocities of water in earth canals, for different materials, which vary between the values given in the table at the foot of this page.

No paving is shown on the plans for the tailrace proper, where high velocities are bound to develop on account of its small section and steep grade. Chief Engineer Mercier, in his report of the 16th December, 1916, recognizes fully the necessity of lining with concrete that section of the aqueduct, and states that it is the intention to provide for same. We fully endorse Mr. Mercier's decision in this regard.

In view of the description of the material given by the Board of Investigation for the conduit, and other information as mentioned above, and after having inspected the works, we have concluded that for the first scheme to be considered, that of the work as per present plans, we could not assume a higher permissible mean velocity for the earth sections of the headrace than 1.5 feet per second.

In our studies, under the heading of Scheme 1, we assume that the bottom is safe for a mean velocity of 1.5 feet per second (1.02 miles per hour), but we cannot, however, accept or recommend this, or any other velocity, until thorough tests have been made to ascertain what velocity it will be safe to assume in order to guard against scouring of the bed and against the undermining of the side-retaining walls.—*(Concluded in the next issue.)*

Table Showing Figures Taken as Authoritative for Velocities in Earth Canals.

	Safe bottom velocity in feet per second.	Safe bottom velocity in miles per hour.	Mean velocity in feet per second.	Mean velocity in miles per hr.
Soft earth	0.25 to 0.50	0.17 to 0.34	0.33 to 0.65	0.23 to 0.44
Clay	0.26 to 0.50	0.18 to 0.34	0.33 to 0.65	0.23 to 0.44
Sand	0.4 to 1.00	0.27 to 0.68	0.6 to 1.3	0.41 to 0.89
Gravel	2.0 to 2.6	1.36 to 1.77	2.62 to 3.0	1.78 to 2.05
Broken stone	3.3 to 4.3	2.25 to 2.93	4.0 to 5.5	2.73 to 3.75

(The concluding portion of this report, outlining schemes 1, 2, 3, 4 and 5, will be published in the next issue of The Canadian Engineer.)